Ballantine

3/24 DIGITAL MULTIMETER

BALLANTINE LABORATORIES

P.O. Box 97, Boonton, New Jersey 07005 U.S.A.
201-335-0900/TWX: 710-987-8380

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3/24 DIGITAL MULTIMETER

WARRANTY

All Ballantine Laboratories, Inc. products are warranted to the purchaser against defects in materials and workmanship. This warranty applies for one year from the date of delivery, except for vacuum tubes and batteries, or, in the case of certain major components listed in the instruction manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period and returned prepaid to Ballantine. No other warranty is expressed or implied. We are not liable for consequential damages. The warranty must be registered within 10 days of receipt of the instrument.

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90100291A **SEPTEMBER 1973**

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SECTION 1
GENERAL INFORMATION

The Ballantine 3/24 Digital Multimeter is an ultra compact precision measuring instrument. It weighs but two pounds (900 gm) with battery and is extremely rugged and easy to use.

A full three digit solid state monolithic gallium arsenide phosphide integrated circuit provides readout. An ultra simple and reliable ramp comparator provides analog to digital conversion. One LSI chip provides complete digital logic control and minimize the number of electric parts. All together three integrated circuits and a minimum number of "off the shelf" discrete components provide utmost reliability and economy. The 3/24 is designed to be maintained by technicians in the field and no special tools or components are required.

Another feature of the Ballantine 3/24 is a unique power converter which uses capacitors to store energy and transform voltage levels. The entire power consumption of the measuring circuit is but 60 milliwatts which makes possible operation from a "throw away" battery, which typically requires replacement only after 300 hours of service.

The 3/24 is easy to use. It incorporates an auto-zero circuit, display brightness control and automatic polarity.

The two front panel rotary selector switches permit selection of ac and dc voltage, ac and dc current and six resistance ranges. Accurate measurements may be made on 24 ranges.

Accessories are available to further increase the usefulness and measuring capabilities of the instrument. These are listed in Table 1-1.

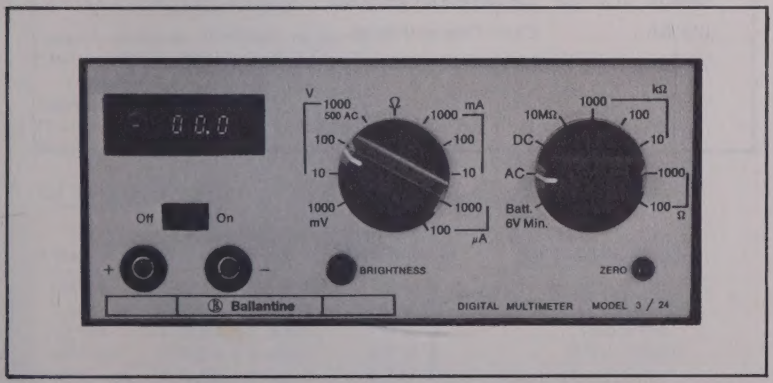

FIGURE 1-1. BALLANTINE 3/24 DIGITAL MULITIMETER

TABLE 1-1. AVAILABLE ACCESSORIES

MODEL NUMBER	DESCRIPTION
3/24	Complete Multimeter with drycell battery
32401A	DC Input Adapter
32402A	AC Input Adapter UL Listed for 115 V
32402B	AC Input Adapter 230 V
32403A	AC Input with Rechargeable Batteries
800-08	Rack mount for three 3/24
38100501L	One third rack cover plate for unused sections of rack mount
12617A	BNC Input Adapter
Series 600	ac/dc Current Shunts (605, 3A & 606, 10A)
10800A	High Voltage Probe 30 kV dc
10830A	ac Test Probe 10:1, input capacity 16 pF
10850A	RF Probe to 100 kHz to 500 MHz
10810A	Universal Test Lead Kit
32405A	Carry Case with strap
32406A	Service Kit containing 2 batteries and 10 spare fuses

TABLE 1-2. SPECIFICATIONS

Reference Conditions 23°C ±1°C

DC VOLTAGE

4 Ranges	Accuracy as % of Reading	Maximum Continuous Overload
1000 mV	± (0.2% + 1 digit)	350 V
10 V	± (0.5% + 1 digit)	1 kV
100 V	± (0.5% + 1 digit)	1 kV
1000 V	± (0.5% + 1 digit)	1 kV

Input Impedance: 10 Megohms
Normal Mode Rejection: >30 dB at 50 Hz, >32 dB at 60 Hz
>40 dB at 100 Hz
Common Mode Rejection: Essentially infinite with battery power (1 kΩ unbalance)
Long Term Accuracy: Within 1% per year 10°C to 30°C
Reading Rate: 3 per second
Temperature Coefficient: Less than 0.02%/°C
Response Time: Typically ≤1 second

AC VOLTAGE

Average responding, calibrated in rms of sine wave

4 Ranges	Accuracy as % of reading	Frequency Range	Maximum Continuous Overload
1000 mV	± (1% + 2 digits)	40 Hz to 20 kHz	350 V to 2 kHz
10 V	± (1% + 2 digits)	40 Hz to 20 kHz	500 V to 20 kHz
100 V	± (1% + 2 digits)	40 Hz to 1 kHz	500 V to 1 kHz
500 V	± (1% + 2 digits)	40 Hz to 1 kHz	500 V to 1 kHz

Input Impedance: 10 Megohms shunted by 75 pF
Common Mode Rejection: (1 kΩ unbalance) Essentially infinite with battery operation
Reading Rate: 3 per second
Response Time: Typically 1 to 3 seconds
Temperature Coefficient: less than 0.05%/°C

DC CURRENT

5 Ranges	Accuracy as % of reading	Approximate Voltage Drop	Overload Protection
100μA	± (0.5% + 1 digit)	1.0 V	1.6A Fuse (Max. Input)
1 mA	± (0.5% + 1 digit)	1.0 V	
10 mA	± (0.5% + 1 digit)	1.0 V	
100 mA	± (0.5% + 1 digit)	1.0 V	
1000 mA	± (0.5% + 1 digit)	1.2 V	

Reading Rate: 3 Readings/sec
Temperature Coefficient: Less than 0.02%/°C
Normal Mode Rejection: >30 dB at 50 Hz, >32 dB at 60 Hz,
>40 dB at 100 Hz
Off Ground Operation: 1000 V DC Maximum; 600 V AC Maximum
Long Term Accuracy: Within 1% per year, 10°C to 30°C
Response Time: Typically 1 to 3 seconds

AC CURRENT

5 Ranges	Accuracy as % of reading	Approximate Voltage Drop	Frequency Range
100μA	± (1.5% + 2 digits)	1 V	40 Hz to 2 kHz
1 mA	± (1.5% + 2 digits)	1 V	40 Hz to 20 kHz
10 mA	± (1.5% + 2 digits)	1 V	40 Hz to 20 kHz
100 mA	± (1.5% + 2 digits)	1 V	40 Hz to 20 kHz
1000 mA	± (1.5% + 2 digits)	1.2V	40 Hz to 20 kHz

Overload Protection: 1.6 Amp Fuse (Max. Input)
Reading Rate: 3 Reading/sec
Response Time: Typically 1 to 3 seconds
Off Ground Operation: 1000 V DC; 600 V AC
Common Mode Rejection: Essentially infinite with battery operation
Temperature Coefficient: 0.05%/°C

RESISTANCE

6 Ranges	Accuracy as % of reading	Measuring Current
100 Ω	± (1% + 1 digit)	10 mA Max.
1000 Ω	± (1% + 1 digit)	1 mA
10 kΩ	± (1% + 1 digit)	100 μA
100 kΩ	± (1% + 1 digit)	10 μA
1000 kΩ	± (1% + 1 digit)	1 μA
10 MΩ	± (1% + 1 digit)	0.1 μA

Protection: ±10 Volts above which 100 mA fuse operates
Reading Rate: 3 Readings per second
Response Time: Typically 1 second
Temperature Coefficient: 0.05%/°C on all ranges except 10MΩ range 0.15%/°C

ENVIRONMENTAL

Operating Temperature: −10°C to +50°C
Storage Temperature: with Batteries (NiCAD) (C-Zn) −40°C to +75°C;
−40°C to +60°C; −20°C to +55°C
Humidity: 0 to 85% RH to 40°C and 80% RH to 50°C
Altitude: to 3 km (15,000 ft.)

GENERAL

Maximum Voltages: Leads to any part of case – 1000 Vac 60 Hz (MIL-STD-202)
Common Mode: Battery Operated – 1000 V DC;
AC Supply – 1000 V DC, 600 V AC
Leads to Ground – 1000 V DC, 600 V AC
Display: 3 digit LED, 7 segment with magnifier. Digit Height 4.5 mm (3/16 inches) Decimal points, negative sign.
Brightness Control: Front Panel control optimizes display brightness and power conservation
Maximum Reading: ±999
Overrange: Useable to 20% overrange (1200).
Overrange Indicator: Left most digit flashes when display exceeds all "nines".
Polarity Indicator: Solid state LED minus sign and auto polarity circuit in DC Modes
Display Storage: Display updates with only changed digits varying at reading rate of 3 per second.
Auto Zero: Automatic zero circuitry, with front panel zero control for offsets and "low ohms" lead compensation
Size (Overall): Width: 14 cm (5.5"); Height: 6 cm (2.4"); Depth: 18 cm (7.1")
Weight: Without batteries – 570 gm (1.25 lbs.)
With batteries – 900 gm (2 lbs.)

POWER

Standard dry-cell battery: 9 Volt Battery – 6.2 to 9 V to 45 mA Approximately 300 hours capacity in 8 hour per day operation.

OPTIONS

32401A External dc Input Adapter: 9.8 to 34 V DC Input, 100 mA max. DC Input must have floating common.
32402A ac Line Adapter: 95 to 135 Volts – 48 to 420 Hz 3 Watts input. Plug mounted. Stores in battery compartment. UL Listed.
32402B ac Line Adapter: Unit fits into battery compartment and performs as above 100 to 125 V and 200 to 250 V.
32403A Rechargeable Battery Supply: Unit fits into battery compartment. Ni-CAD battery provides 16 hours of service from fully charged battery. 16 hour recharge cycle. 95 to 130 and 200 to 250 V – 48 to 420 Hz input 5 Watts Max. Switch selects: battery operation; AC operation with trickle charge; or battery charge.

ACCESSORIES

The 3/24 is supplied with:
1 pair Test Leads
1 Instruction Manual
1 Battery
1 each Spare Fuse, 1.6A
1 each Spare Fuse, 100 mA

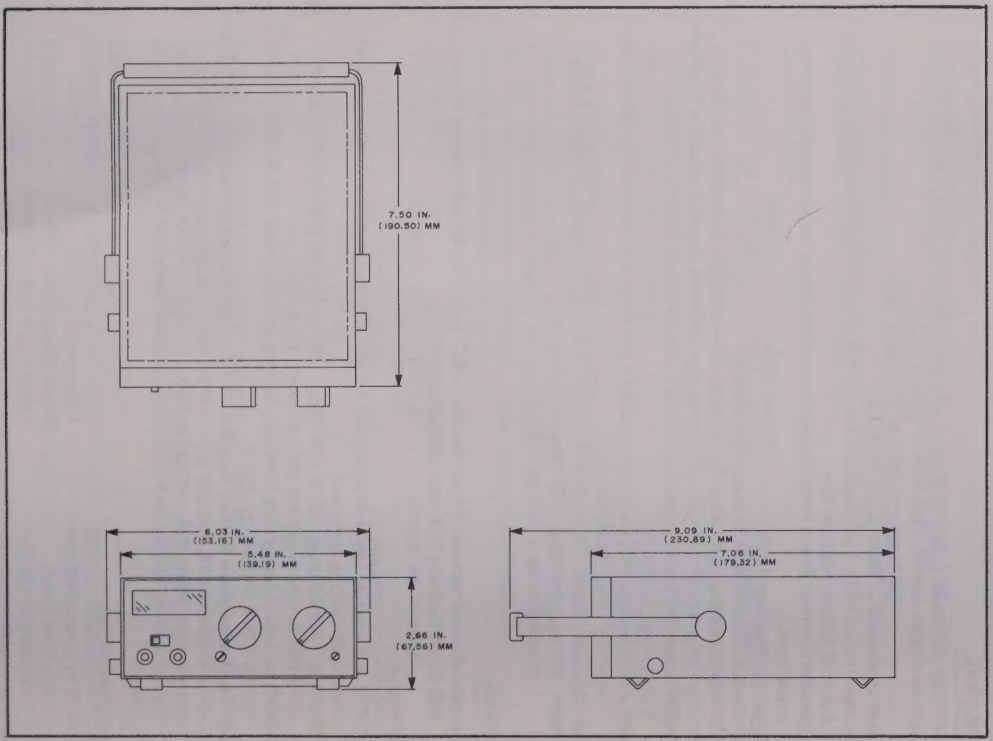

FIGURE 1-2. OUTLINE DRAWING

TABLE 1-3. SPECIFICATIONS OF ACCESSORIES

10800A HIGH VOLTAGE DC PROBE

Voltage Range: 1000 V to 30 kV DC
Input Resistance: 1000 MΩ
Division Ratio: 1000:1 adjustable ±10% Calibrated to 10M Ω input
Operating Temperature Range: −10°C to +50°C
Humidity Range: 0 to 85% RH
Cable Length: 1.5 meters (5 ft.)
Ground Lead Length: 1.5 meters (5 ft.)
Accuracy (long term stability and power coefficient): ±1%
Voltage Coefficient: 2 ppm/V to 10 kV; 3 ppm/V to 20 kV; 5 ppm/V to 30 kV

10830A AC/DC TEST PROBE

Input Resistance: 10 MΩ
Input Shunt Capacity: 16 pF
Cable Length: 1 meter (3½ ft.)
Response: Flat from dc to beyond 100 kHz
Maximum Input Voltage: 600 Volts dc + peak ac
Accuracy: ± (2% +Meter range Accuracy) Compensator adjustable for ±5% calibration.
Terminating Impedance: 10 MΩ/45 to 80 pF DMM Input Impedance.
Accessories:
1 — Banana (4mm) tip
1 — Alligator tip
1 — Ground lead — 20cm (8")
1 — Straight pin tip

10850A RF PROBE

Input Voltage: ac to 0.25 to 30 V; dc 200 V max
Response: Peak responding, calibrated in rms of a sine wave, usable 100 kHz to beyond 525 MHz
Accuracy: Typically within ±0.5 dB to 200 MHz; ±1 dB to 270 MHz; ±3 dB to 470 MHz. Calibration adjustable to ±1% at any frequency to 250 MHz
Input Impedance: 2 MΩ shunted by 2 pF
Terminating Impedance: 10 MΩ shunted by $<$200 pF.
Accessories: 1 — BNC High Frequency Adapter Tip
1 — Ground Lead — 20 cm (8")
1 — Straight Tip
Cable: 1 meter (3½ ft) Compensator termination with banana plugs on 3/4" centers.

SECTION 2
INSTALLATION AND OPERATION

2-1 INTRODUCTION

This section contains information on the installation and operation of the Ballantine Model 3/24 Digital Multimeter. The contents of this section should be fully understood before any attempt is made to operate this instrument. If assistance should be required or any difficulties encountered, please contact your nearest Ballantine distributor, field engineering representative, or:

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Ballantine maintains comprehensive sales and service representatives throughout the world. Ballantine voltmeters have been world famous for over 40 years and our product line includes a comprehensive range of counters, oscilloscopes, calibrators and voltmeters. We are ready and eager to assist you in your measurement needs and to be of service to you.

2-2 INPUT POWER

The Ballantine 3/24 is supplied with one of four input power options:

Dry Cell Battery, (standard); 9V, 7.5 mm x 50 mm x 60 mm (3" x 2" x 2½") with snap-on terminals.

The following batteries are available worldwide:

Worldwide	IEC 6F 100; NEDA 1603
USA	Burgess D6; RCA VS306; Mallory M1603: Eveready 276
U.K.	PP9; VT9; RR9; M1603: 439
Germany	439; 339; 495
France	6NX; R0614
Italy	592; 995; A23
Scandinavia	480; 780; LP5M9; 439; 9T1
South Africa	PM9; FM9; EF/EM
Spain	PT673
Japan	N572; 306
Australia	276

DC INPUT

The 3/24 may be operated from any filtered dc source having 50 mA supply capability and a loaded voltage of 6.2V dc to 10V dc. No adapter is required for this direct substitution of the internal battery within the above voltage limits. A voltage reducing network or Ballantine 32401A dc adapter must be used when operating from a 12 Volt lead acid storage battery.

Ballantine 32401A dc adapter contains a voltage regulator which permits operation of the DMM from 9.8V dc to 34V dc. Current requirements are 10 to 100 mA depending on input voltage and setting of display brightness.

CAUTION

The external dc supply must always be fully floating with respect to the test leads of the multimeter! At no time may the dc supply input be connected to the meter leads or to the circuit system on which measurements are being made. Failure to observe this precaution may damage the multimeter and void the warranty.

AC POWER SUPPLY

The Ballantine 32402A is a UL listed plug-mounted power supply. It operated from 100 Volts to 135 Volts ac from 48 Hz to 450 Hz. Power is nominally 3 Watts.

A flexible 2-wire cable carries the low voltage dc from the plug to the multimeter making it extremely easy to use the instrument in the field.

The supply is listed for 115 Volt supply input by the Underwriter's Laboratory and is safety tested for use in schools, hospitals, and in conjunction with U.L. equipment requiring the ultimate in personnel safety.

The multimeter may be operated off ground to 1000 Vdc or 600 Vac between either of the instrument input terminals and ground. The ON-OFF switch does not disconnect the ac supply.

The ac supply may be disconnected and replaced with a dry cell (carbon zinc) battery for off line operation.

When not in use, the 32402A ac supply may be stored in the battery compartment of the multimeter.

For 230 Volt operation, the 32402B supply is available. In use it fits into the battery compartment and operates from 100 to 125 and 200 to 250 Volts.

RECHARGEABLE BATTERY SUPPLY

The Ballantine 32403A rechargeable NI-Cad supply will operate the multimeter for more than 16 hours under nominal conditions of environment and display brightness. It incorporates a charger circuit which will fully recharge the batteries in 16 hours at room ambients when the multimeter is switched OFF.

The unit fits into the battery compartment and includes a three position switch for ac operation, battery operation with trickle charge, and battery charge.

The 32403A may be used from $-10^{\circ}C$ to $+50^{\circ}C$, but recharging should be accomplished from $+10^{\circ}C$ to $+40^{\circ}C$.

The charger operates from 100 to 125 and 200 to 250 Volts ac, 48 to 420 Hz.

CAUTION

Be sure the instrument is applied within specified ratings. Recheck this manual and the decal at the underside of the instrument. Application of improper power levels or sources may effect instrument accuracy and cause damage as well as voiding the guaranty.

2-3 RACK INSTALLATION

The Ballantine 3/24 may be mounted in a standard 19 inch rack when supplied with the Ballantine 800-08 rack mounting kit.

The small size and low power consumption permit one, two or three multimeters to be mounted next to one another in the 3½ inch high rack adapter.

The multimeter may be placed on either side or centered in the adapter. One-third rack width covers (38100501L) may be used to fill unused panel space in the 800-08.

Each multimeter should have its own power supply or battery since the power source is not common with the instrument input terminals. The 32402A ac supply is recommended for use with each instrument.

See Fig. 2-1 for rack mounting dimensions.

2-4 OPERATING CONTROLS AND FEATURES

See Fig. 1-1.

2-5 SPARE FUSES

One each 1.6A and 100 mA fuse are provided as spare parts with the multimeter. These spare fuses are located in the battery compartment, and/or are fastened to the battery.

The Ohmmeter circuitry is protected from accidental over voltage (>10V) by a miniature (5 mm x 20 mm) 100 mA fuse. Ballantine Part No. 19100120A (FS-1).

The Ammeter circuitry is protected from overload damage with a 1.6 Ampere miniature (5 mm x 20 mm) fuse. Ballantine Part No. 19100130A (FS-2).

See paragraph 4-4 for fuse replacement instructions.

2-6 INPUT CONNECTIONS

Two "banana" input terminals are provided on the multimeter front panel. All measurements are made across these two terminals thereby providing simplified operation.

The terminals are marked plus and minus. *Neither is connected to circuit ground (chassis) or to the battery power input leads.*

2-7 OVERLOAD INDICATION

Overloads are indicated by the flashing of the most significant (lefthand) digit. Specified accuracy is maintained to 120% of full scale. When overload is signalled,

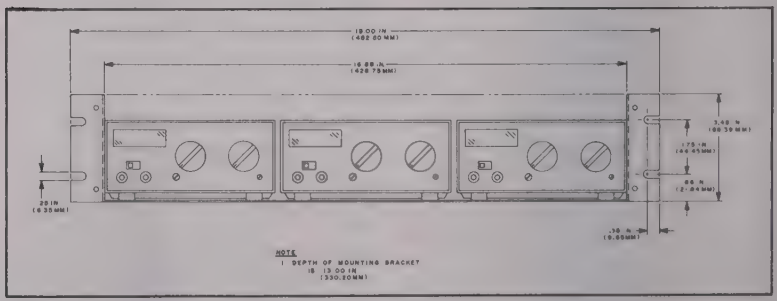


FIGURE 2-1. RACK MOUNTING DRAWING

simply turn the rotary switch to the next highest range until the DMM is on the proper range for the signal being measured and the flashing ceases.

2-8 OPERATION AND CONTROLS

ON/OFF slide switch on the front panel to turn off the instrument when not in use. The ON/OFF switch disconnects the internal battery or dc input — it does not switch the ac power input.

Always turn off the instrument when not in use to maximize battery life.

BRIGHTNESS panel control to adjust display brightness for ambient light conditions. Battery life will be extended by adjusting the control for lowest usable brightness.

ZERO panel screwdriver control to permit precise zero adjust on all ranges including the 100Ω Ohmmeter range. Select 1000 mV dc range and connect (short) the input leads together. Adjust ZERO control for a reading of 000 or −000.

Test lead resistance may cause 0.1 to 0.3Ω or greater offset error. The zero control may be used to eliminate this offset of test lead resistance. Adjust for zero with test leads shorted. Always remember to reset zero on 1000 mV dc range after using 100Ω Ohmmeter range to restore multimeter to normal zero operation.

INPUT CONNECTIONS. Two "banana" input terminals are provided on the multimeter front panel. All measurements are made across these two terminals thereby providing simplified operation.

The terminals are marked plus (+) or minus (−). Neither is connected to ground (chassis) or to the battery power input. The plus (+) terminal is the low potential (dc or ac Lo) terminal with respect to ground when using ac line operated power supplies.

RANGE AND FUNCTION SELECTION Two rotary switches are located on the front panel to provide 24 operating ranges and a 25th range for battery check.

These rotary selector switches are carefully arranged to provide simplified selection of all ranges and functions. This permits accidental misconnection of the ohmmeter and permits use of only two input terminals.

MEASURING RANGES are listed in Table 2-1.

NOTE

A flashing display indicates overload. Switch the appropriate range switch to the next higher range until a steady display appears. Flashing lefthand digit of the display and an indication of less than 200 indicates a reliable reading at full specified accuracy between 1000 and 1200. This overrange provides accurate readings within the maximum ratings of the multimeter on all ranges except the 100 μA AC current range.

To prolong switch life:

a) **DO NOT** operate range selectors when the instrument is connected to an inductive circuit.
DO disconnect the test leads when range switching inputs from an inductive source.

TABLE 2-1. MULTIMETER MEASUREMENT CAPABILITY

Measurement	Function	Full Scale Range	Resolution	Accessories	Remarks
DC Volts	DC mV	1000 mV	1 V	Extends to 30 kV with	Auto Polarity.
	DCV	10 V	10 mV	Model 10800A	Probe is optional.
		100 V	100 mV	1000:1 H.V.	
		1000 V	1 V	probe	
DC Current	DC μA	100 μA	0.1 μA		Auto Polarity.
		1000 μA	1 μA		
	DC mA	10 mA	10 μA		Fuse protected
		100 mA	100 μA		to 1.6 Amps.
		1000 mA	1 mA		
AC Volts 40 Hz to 20 kHz Average Responding (Calibrated in RMS of sinewave)	AC mV	1000 mV	1 mV		AC Lo to low side when using AC power accessory only. Probe is optional.
		10 V	10 mV		
		100 V	100 mV		
		500 V	1 V		
AC Current Average Responding (Calibrated in RMS of sinewave)	AC μA	100 μA	0.1 μA		Fuse protected to 1.6 Amps.
		1000 μA	1 μA		
	AC mA	10 mA	10 μA		
		100 mA	100 μA		
		1000 mA	1 mA		
Ohms	Ω/Ω	100 Ω	0.1 Ω		Operating voltage and current limited to 1V and 10 mA.
		1000 Ω	1 Ω		
	Ω/kΩ	10 kΩ	10 Ω		Fuse protected for over voltage beyond 10 Volts.
		100 kΩ	100 Ω		
		1000 kΩ (1MΩ)	1000 Ω		
	Ω/kΩ	10 MΩ	0.01 MΩ		
AC Volts R-F probe 500 MHz. Sine wave peak responding (positive) calibrated in RMS	DCV	1/10 V	10 mV	Extends beyond 500 MHz with Model 10850A detector probe.	Probe is optional.
		250 mV to 30 V RF Input			

b) Select the 1000 mA current range **BEFORE** currents greater than 100 mA are applied to the multimeter.

RESISTANCE MEASUREMENT.

When measuring resistance, select the Ω (OHMS) switch position.

No other selection of inputs or function is required.

Select the appropriate range from the six Ohms range switch position. Position the resistance to be measured between the plus (+) and minus (—) terminals. If the resistance to be measured is connected to ground and the ac input power accessory 32402A is used, it is preferable to connect the grounded end of the circuit under test to the plus (+) terminal.

When using the 100Ω range for low resistance measurements, the resistance of the multimeter test leads will cause a 0.2Ω or greater offset error. The **ZERO** control on the front panel may be used to cancel lead resistance. Short the test leads together and adjust the display for 00.0. Always reset the **ZERO** on the 1000 mV dc range after using the 100Ω range to restore your 3/24 to proper calibration on all other ranges.

The 3/24 Ohmmeter range is current limited to 1 mA maximum on the 100Ω range and this limit reduces in decade steps to 0.1 μA on the 10 MΩ range. The Ohmmeter full scale loaded measuring voltage is 1 Volt dc to permit safe measurement of transistors, diodes and other semiconductors.

Always turn off power from the circuit being measured when making "in circuit" resistance measurements.

This assures accurate OHMS readings and avoids accidental over voltages on the DMM Ohmmeter input. The 3/34 is fully protected against accidental application of voltage to the Ohmmeter input. Internal limiters protect the Ohmmeter and all its ranging resistors to 10 Volts dc. Above 10 Volts a 100 mA fuse (FS1) protects the Ohmmeter from damage. Always check this fuse if the Ohmmeter appears to malfunction. See paragraph 4-4 for fuse replacement instructions.

A high current drain from the internal battery is required on the 100Ω range and battery life will be shortened if left on this range for extended periods of time, or with the test leads connected together (shorted). Also note that a BAT CHK reading of less than 650 may indicate a battery too drained to power the display and the 100Ω range. Always check battery condition when the instrument appears to operate incorrectly on the 100Ω range.

DC MEASUREMENTS

DC voltage and current requirements are listed in the specification.

DC voltages and currents may be measured even in the presence of unwanted ac voltages. The multimeter incorporates internal rejection filters for ac voltages appearing in series with the dc voltages and currents to be measured.

The AC Series Mode Rejection provided is:

>30 dB at 50 Hz
>32 dB at 60 Hz
>40 dB above 100 Hz

Off Ground Operation. Floating the unit off ground is permissible and is simplified by the self-contained battery power source.

CAUTION

The Voltmeter will safely withstand 1000 Volts dc or peak ac (to 60 Hz) from either input terminal to any part of the case. (Measured at 60 Hz per MIL-STD-202.) DO NOT exceed this voltage or serious personnel hazard may result.

When using the ac power adapter 32302A or the rechargeable battery supply 32403A (connected to the ac power line), DO NOT apply more than 1000 V dc or 600 V ac rms between either multimeter input terminal and power line ground (earth).

Input Resistance. The input resistance of the multimeter is <10 megohms on all dc voltage ranges. This high resistance minimizes "loading" of the circuit under test by the multimeter.

Voltage readings are, therefore, possibly higher and more accurate than readings taken with a general purpose lower input impedance multitester (which may present a typical load of 20,000 Ohms per Volt of its voltage range setting.

dc Ammeter. This function incorporates a low resistance shunt to measure the current in the circuit to be tested. An Ammeter connection is always in series with the load. If current through the Ammeter shunts exceeds 1.6 Amps, fuse FS2 will open to protect the multimeter. The operator should set up all current measurements with this in consideration. The voltage drop across the shunts is approximately 1 Volt on all lower ranges and 1.2 Volts on the 1000 mA range. The 1000 mV system is used to measure the voltage drop caused by the current to be measured as it passes through the shunt resistors.

Ballantine also offers the Series 600 external shunts to measure currents to 10 amperes dc and ac to beyond the frequency limitation of the DMM.

AC MEASUREMENTS

AC Voltages and currents may be measured over a range of at least 40 Hz to 20 kHz.

AC Voltmeters which respond to average or peak values are calibrated in rms voltage based on sine wave input voltages.

If the voltage under test is not sinusoidal, the resulting measurement error may be considerable. The amount of error depends upon the number and percentage of harmonics present as well as their phase relationships.

The 3/34 DMM is average responding, but calibrated in rms of a sine wave. The 10850A RF probe accessory for the DMM is peak responding and is calibrated in rms of a sine wave. RMS calibration is used since rms give the true measure of the power capability or heating value of the input waveform. Ballantine offers other instruments such as the Model 323 which respond to the *True rms* of the input waveform. A *True rms* instrument should always be used to measure ac voltages which have considerable harmonic content or non-sinusoidal voltages such as may be found in ac/dc rectifiers, SCR devices, pulse trains, square waves, inductive loads, power measurements, noise measurements, etc.

An unknown voltage which is not sinusoidal may be displayed and analyzed on an oscilloscope. A meter however, can not give an indication of this kind, and the user cannot know from a digital or analog voltmeter presentation what distortion might be present in the signal under test.

Figure 2-2 shows the voltage relations of a sine wave. For each half cycle

$$E_{rms} = 0.707 \times E_{peak}$$

$$E_{avg} = 0.636 \times E_{peak}$$

The peak to peak voltage is measured between the peaks of the positive and negative half cycles and is equal to $2 \times E_{peak}$. It is the arithmetic sum of the two peak values. Figure 2-2 provides a

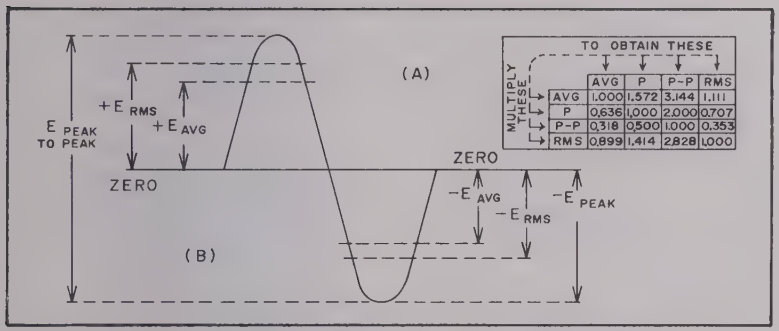


FIGURE 2-2. SINE WAVE VOLTAGE RELATIONS

simple table for converting any sine wave value to the other values. As an example, simply multiply peak to peak by 0.353 to obtain the rms value.

Care must be exercised by the operator to minimize test lead capacity to minimize loading of the circuit under test. The input to the multimeter is shunted by nominally 75 pF and <10 megohms. Open test leads may add another 25 pF to 50 pF (or more if leads are twisted or run over a "ground plane").

The loading factor of the shunt capacitance may be determined by the following relationship:

$$X_c \text{ (Ohms)} = \frac{1}{2\ \pi \text{fc (Frequency) F (Capacity)}}$$

Example for 100 pF shunt capacity at 10 kHz:

$$X_c = \frac{1}{6.28 \times 10{,}000 \times 100 \times 10^{-12}}$$

$$= \frac{1}{6.28 \times 10^{-6}} = 160{,}000\Omega \text{ of capacitive reactive loading.}$$

160,000Ω is only 1.6% of the 10MΩ shunt resistance but may present a considerable error when it loads an ac test point. In fact, to achieve less than 1% error in multimeter reading accuracy due to capacitive loading, the test point source impedance must be <1/100 of the DMM capacitive loading. In the foregoing example the test point impedance must be less than 1,600Ω if the error is to be less than 1% or 160Ω if less than 0.1%.

The loading effect becomes more important at higher frequencies but is present even at line frequency.

In addition, ac current will flow in the leads causing more measurement errors. In the above example a 10 Volt signal will cause:

$$I = \frac{E}{X} = \frac{10V}{160{,}000\Omega} = 62.5\ \mu A$$

to flow through the test leads.

To minimize capacitive loading and to provide shielding of the test leads, use of the Ballantine 10830A attenuator probe is recommended. This 10:1 attenuator

has a 3½ foot shielded cable and will present approximately 16 pF loading when compensated to the multimeter input. Probe division ratio is 10:1 and the multimeter display must be multiplied by 10 times to read the input voltage. The probe may be used for both ac and dc measurements to 10 kHz and 600 V ac rms. Accuracy is typically ±2% from dc to 20 kHz. It may be compensated by means of a constant amplitude sine wave source simply by equalizing the multimeter reading with the compensating trimmer supplied in the probe termination while varying probe input frequency from 40 Hz to 20 kHz at 5 Volts rms input. Switch the multimeter to 1000 mV ac and read 500 mV.

The ac voltage or current to be measured may be "off ground." The multimeter must reject the off ground ac or dc "common mode" voltage. It will do so with virtually infinite rejection when the instrument is "off line" operated from batteries.

For off ground operation exercise the same care and safety precautions given under dc Measurements described previously.

When using the ac power adpater use the ac LO input connector as the "low potential" point to system ground (earth). This minimizes common mode signal errors. Determine if the multimeter reads ac voltages when the test leads are shorted together and tied to "high" side of the ac signal to be measured. If a reading of some magnitude is displayed on the multimeter use battery power and disconnect the ac power line.

When using ac power, the off ground voltage between the ac LO input connector and earth, ground should not exceed 1000 V dc or 600 V rms ac.

BATTERY CHECK

A BAT CHK position is provided on the right hand rotary switch. To check battery condition select BAT CHK and any dc voltage range. Disregard the decimal point.

The display reading does not indicate actual battery voltage but rather checks battery voltage and source impedance. The following table indicates the approximate life remaining in the battery for different display readings:

Reading	>980	800	750	690	600
Life	100%	75%	50%	25%	0

The ability to measure remaining battery life is a unique feature of the Ballantine 3/24.

Battery life varies with the capacity of the battery and is possibly different for batteries that have been stored for some time or are produced by different manufacturers. Battery life is always affected by environment, rate of current drain, length of discharge cycles. The 3/24 features a display BRIGHTNESS control so that only the minimum battery drain is required to suit the operator and ambient light conditions. Under typical conditions of 4 hours of use per day and limited brightness, one fresh battery should provide up to 75 working days (300 hours) of service.

Battery check may also be used to test for adequate supply voltage when using the dc power adapter (32401A), the ac power adapter (32402A/B), or the rechargeable battery supply (32403A). Higher check readings may be anticipated. Overrange (flashing) to a reading of 080 is indicative of a good supply since

the display does NOT read the supply voltage.

DO NOT use the DMM input leads to measure battery or supply voltage, since the battery floats in respect to DMM ground.

2-9 OVERLOAD PROTECTION

Overloads are indicated by the flashing of the most significant (lefthand) digit. Full specified accuracy is maintained to 120% of full scale except on the 100μA ac current range. A flashing "1" in a display showing "199" indicates a reading of 1199.

It is a feature of the 3/24 that only two input connectors and leads are required for all measuring modes.

The following overload protection is provided:

DC Voltage. 1 kV on all ranges except the 1000mV range where protection rating is 350 Volts. These ratings are maximum for continuous overloads.

AC Voltage. 500 V rms sine wave on all ranges (or 1400 V peak to peak) except the 1000mV range where the protection rating is 350 V rms of a sine wave (or 980 V peak to peak).

These sine wave ratings apply from 40 Hz to 2 kHz on the 1000mV range, 40 Hz to 20 kHz on all other ranges. The overload voltage should not rise or fall faster than 2×10^7 Volt-Hertz on a non-recurring peak basis nor continuously exceed 2×10^6 Volt-Hertz on the 1000mV range and 2×10^7 Volt-Hertz on all other ranges.

Ammeter ranges are protected for current overloads beyond 1.6A by FS2. See paragraph 4-4 for fuse replacement instructions. Do not switch current ranges when currents exceed 1A or derive from an inductive source.

The ohmmeter is fully protected on all ranges against damage if the leads are accidentally applied to a voltage source. Fuse FS-1 (100mA) acts to fully protect the ohmmeter multipliers when accidental input overload voltages exceed ±10 Volts (dc or ac rms). See paragraph 4-4 for replacement instructions.

2-10 ATTENUATOR PROBE (Optional) MODEL 10830A

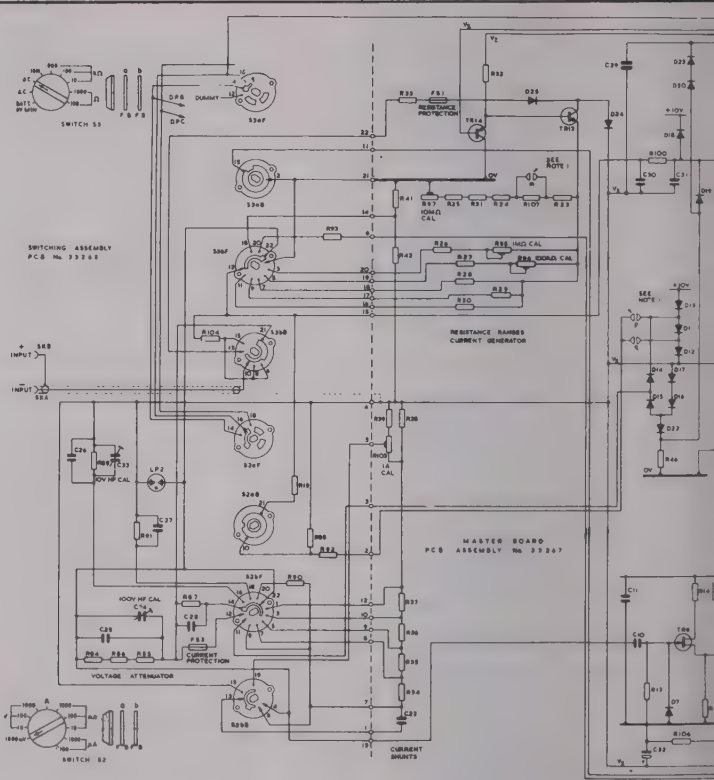
The 10830A is available as an ac/dc test probe to minimize loading of the test point and to provide a simple shielded input lead for ac and dc voltage measurements.

To compensate the probe simply connect it to the 3/24 through the type 12617A BNC to dual banana adapter. Check calibration at 10 Volts dc or 10 V rms 50 to 60 Hz. Increase known 10 Volt rms input signal frequency to 20 kHz an adjust probe compensating trimmer to give same reading on 3/24 as was obtained at the low test frequency. The probe is now compensated.

2-11 RF PROBE (Optional) Model 10850A

The Ballantine 10850A probe is a peak detector probe which provides voltage measurement capabilities for sine waves to beyond 500 MHz. It is a peak detector probe using a semi-conductor diode. Maximum signal is 30 V ac and a blocking capacitor will hold off dc to 200 Volts maximum. **CAUTION** — *Never exceed these ratings.*

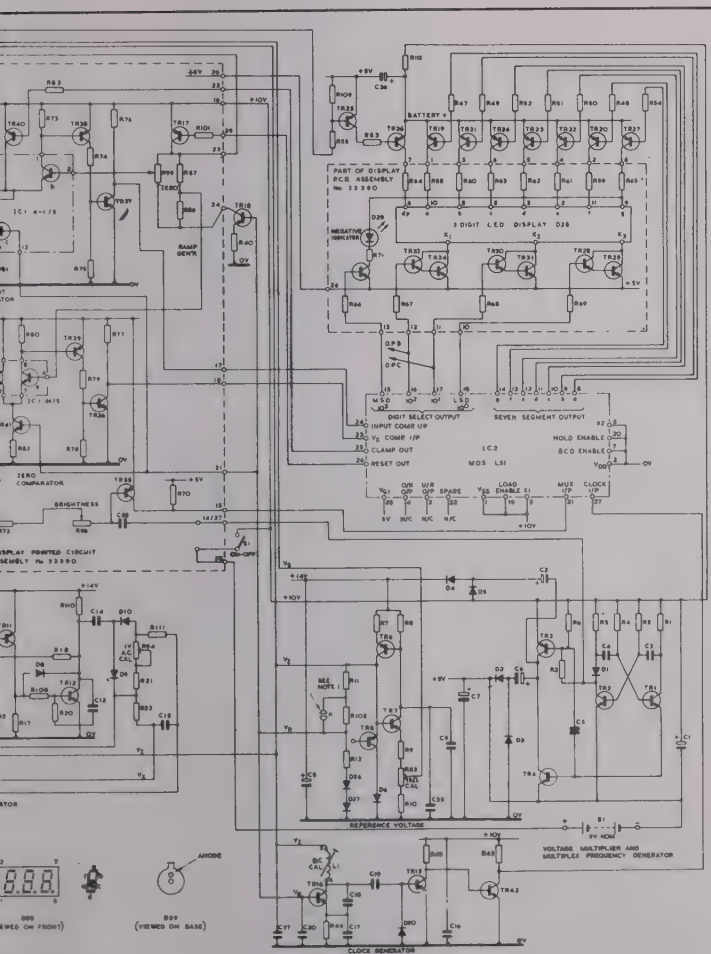
The 10850A is usable from 100 kHz to beyond 525 MHz. It can be calibrated at any frequency with the adjustment provided in the compensating box at the end of the cable. Normal use provides



NOTES

1 SYMBOL —◯— INDICATES COPPER PADS ON THE PRINTED BOARDS WHICH ARE BRIDGED WITH SOLDER DURING TEST TO MAKE CONNECTIONS AS REQUIRED

2 SWITCHES S2 AND S3 ARE VIEWED FROM THE FRONT LOOKING THROUGH THE WAFERS


BATTERY +
3 DIGIT LED DISPLAY D28
DIGIT SELECT OUTPUT
SEVEN SEGMENT OUTPUT
INPUT COMP I/P
COMP I/P
CLAMP OUT
RESET OUT
MOS LSI
HOLD ENABLE
BCD ENABLE
ZERO COMPARATOR
BRIGHTNESS
REFERENCE VOLTAGE
VOLTAGE MULTIPLIER AND MULTIPLEX FREQUENCY GENERATOR
CLOCK GENERATOR
ANODE
(VIEWED ON BASE)

broadband flatness within ±0.5 dB to 200 MHz and −1 dB at 270 MHz. Do not use for signals less than 250 mV or below 100 kHz since the detector time constant is too short. The probe may be used as an AM detector if modulation is in the 100 Hz to 20 kHz bandwidth.

The probe may be calibrated by adjusting it on the 1 Volt or 10 Volt ranges from any known precision ac source within its range. *Always use the 10850A RF probe on the 1000 mV and 10 V dc ranges of the 3/24.*

2-12 HIGH VOLTAGE DC PROBE (Optional) MODEL 10800A

The Ballantine 10800A high voltage probe is used to divide high dc voltages so they may be measured by the multimeter. Division ratio is 1000 to one and is adjustable by ±10% to permit precise calibration of the division ratio of the probe to the multimeter.

Maximum probe voltage rating is ±30 kV dc. At no time should the 30 kV peak rating be exceeded.

CAUTION

ALWAYS connect the ground lead to the circuit under test BEFORE connecting the HV probe. Failure to observe this precaution will apply full high voltage to the instrument and may not only result in instrument damage but may cause a SERIOUS PERSONNEL HAZARD. ALWAYS connect the ground lead first and permanently when using the high voltage probe. Handle the probe only at its black handle and avoid contact with the flash guard and tip area. Use "off line" battery operation when using the HV probe to minimize hazards.

The accuracy of the probe is ±1% plus the accuracy of the 3/24. A voltage coefficient of 0.0002% (2 ppm) per Volt to 10 kV, 0.0003% per (3 ppm) per Volt to 20 kV, and 0.0005% (5 ppm) per Volt to 30 kV is additionally applicable.

The probe is generally used on the 10V and 100V ranges of the multimeter and thus reads directly to 10 kV on the 10V range and to 30 kV on the 100V range.

SECTION 3
THEORY OF OPERATION

3-1 INTRODUCTION

Information on the theory of operation is covered in the individual circuit descriptions. Block Diagram, Figure 3-1, shows the major circuit blocks of the multimeter.

3-2 POWER SUPPLY

The battery (or power supply) is connected between the +5V and +10V supplies and powers a free running multivibrator comprised of TR1 and TR2. The switching of the multivibrator produces the zero Volt supply line by transferring charge (switching) from C6 to C7. Similarly, C2 and C8 are switched to produce the +14V supply.

This unique transfer of charge by a free running multivibrator avoids the use of inductive components in the dc to dc inverter. Using capacitors in this manner is somewhat similar to voltage doubler or peak detector circuits with the multivibrator acting as a chopper or switch to convert the battery dc to ac. Since the entire DMM only requires between 50 mW and 250 mW of power, the capacitive transfer is a simple, reliable, efficient and light weight circuit. An added advantage is the lack of sharp transients caused by switching a transformer, which in turn reduces interference to the measuring and digital circuits as well as minimizing unwanted radiated electrical interference.

TR6 supplies a constant current to TR8 which operates as a Zener regulator to provide a stable reference voltage for the DMM.

3-3 DISPLAY

The three display digits are monolithic LED seven segment numerics. The digits are time shared and sequentially switched on by transistors TR28 through TR34. The seven segments are switched by transistors TR19 through TR27.

The sequential switching of digits occurs at a frequency sufficiently above the visual flicker rate. The switching rate is controlled by the power supply multivibrator. The latter squarewave is fed by TR35 to the multiplex input of MOS large scale integrated circuit IC2. The multiplexed output duty cycle is varied by front panel BRIGHTNESS control R93 and TR35 to control the display brightness and battery drain.

IC2 is a MOS LSI and contains:

- 4 counting decades
- 4 storage latches
- Decoding for multiplexed seven segment displays and digit section output to identify the proper digit to be illuminated.
- Auto Polarity Circuit

The decimal point anode switch is operated by the instrument's rotary range switches.

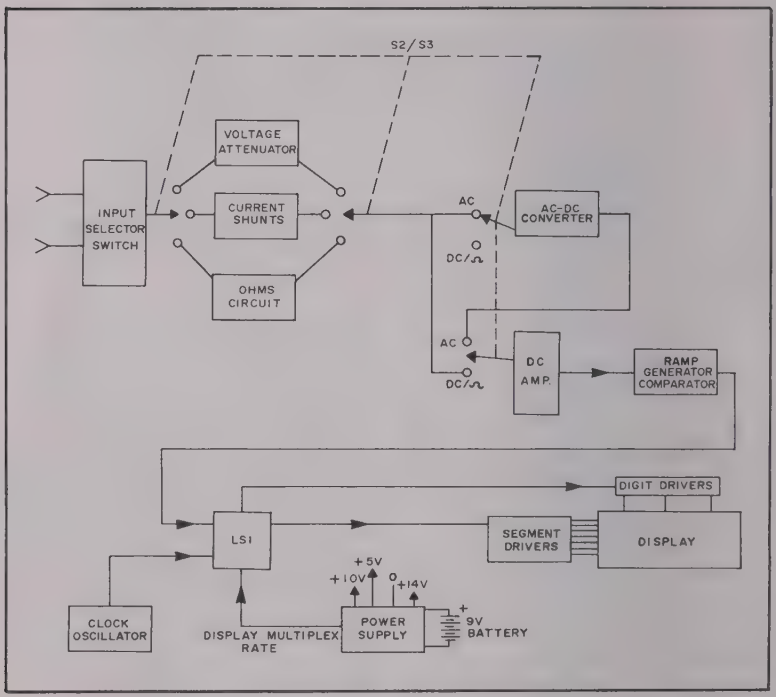


FIGURE 3-1. BLOCK DIAGRAM

3-4 ANALOG TO DIGITAL CONVERSION

The Ballantine 3/24 DMM uses a single negative going ramp generated by C29 and TR18. The ramp is reset approximately three times per second (300 mS) by TR17 and is applied to both comparator amplifiers. The Vx comparator provides the reference while the input comparator provides the unknown dc analog voltage input information.

The two diagrams show the sequence of operation of the two comparators which feed IC2, the MOS LSI. IC2 also contains the dc Auto Polarity Indicator circuits. See Fig. 3-2.

The ramp intercepts generate a time interval which is used in IC2 the MOS LSI.

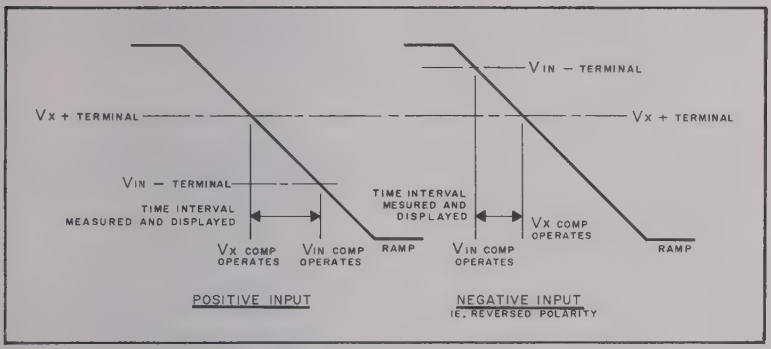


FIGURE 3-2. WAVEFORMS

An oscillator provides a frequency which is counted by the LSI during the measurement time interval. One thousand counts accumulate during a full scale measurement and display accuracy is maintained through 1200 counts providing 20% overrange. In addition, overrange detection circuits in IC2 cause the most significant digit to blink.

The frequency generator is a stable Colpitts oscillator operating at about 200 kHz. Its reference tank is comprised of L1 and the capacities associated with TR16, the oscillator transistor. L1 is tunable to provide precise high resolution calibration with excellent environmental and long term stability. The oscillator is followed by squaring stage TR15 which feeds IC2 through TR42.

The input current flowing into the dc input comparator is reduced by the clamping action of TR40.

3-5 SIGNAL CONDITIONERS

AC to DC converter. The ac to dc converter is a high gain differential amplifier consisting of transistors TR9 through TR12. The ac feedback path is taken from the diode rectifiers at the output of the differential amplifiers. R18 provides dc negative feedback.

The ac to dc converter responds to the average value of the incoming ac signal. The multimeter measures the average value of the input ac and is calibrated in Volts rms.

The ac to dc converter frequency response is controlled from 40 Hz to 20 kHz and beyond at reduced accuracies. It converts for both ac voltage and ac current measurements.

Resistance Measurement. Transistor TR13 is a constant current generator. This known current is passed through the resistor under test.

$$R = \frac{E_m}{I_k}$$

E_m = measured volts

I_k = known current

Since I_k is known, E_m need only be measured to determine the value of the unknown resistance R.

Ohmmeter ranging is performed by changing the value of measuring current by switching resistors in the emitter of TR13.

Voltage Measurement Ranges. The dc voltage measuring circuit uses IC1 as input amplifier. The sensitivity at Pin 4 of IC1 is 0.979 Volts for a display reading of 1.000 (actually 0.999 plus one which shows as 000 with left hand zero flashing).

The input is attenuated by R87 and R19 on the 1000 mV range. For other ranges, the input signal is attenuated by R84 through R86 and switched resistors R89, R91 and R90.

For ac voltage measurements the ac to dc converter is switched in between the attenuator and the dc input amplifier. The attenuator is capacitively compensated to preserve ac accuracy for frequencies to 20 kHz.

Current Measurement. Resistors R34 through R38 are current shunts for the five current ranges. The input current is applied to the tap selected by the switch.

$$I = \frac{E_m}{R_k}$$

The unknown current develops a voltage across the known resistor. This voltage will be measured and is approximately 1 Volt full scale on the 100μA through 100 mA ranges. The voltage drop is 1.2 Volts on the 1000 mA (1A) range.

The ac to dc converter is used in ac current measurements while normal dc input amplifier is used for both ac and dc current measurements.

SECTION 4
MAINTENANCE

4-1 INTRODUCTION

This section contains information on the recalibration, preventive maintenance and corrective maintenance of the 3/34 DMM.

It is intended that the 3/24 be easily maintained in the field and adequate trouble shooting and simple adjustment procedures are provided.

A one year recalibration interval is recommended to assure ±1% accuracy from +10°C to +30°C. In more stringent environments, or where the full precision of the 3/24 is required, Ballantine recommends semi-annual or more frequent certification intervals.

Table 4-1 lists the recommended calibration test equipment. Other equivalent test equipment may be used.

4-2 SERVICE INFORMATION

Ballantine offers a two day turnaround at its factory in Boonton or other authorized service centers. Your instrument is field repairable and the fastest maintenance can always be accomplished easily in your own service shop. Should your 3/24 require Ballantine's attention and recertification, pack it as follows:

a) Remove the battery from the 3/24.

b) Place the 3/24 into an oversize plastic bag and seal the bag.

c) If possible, ship the instrument in its original styrofoam pack. If this foam pack is not available, place the 3/24 into a heavy duty cardboard box which contains at least 2 inches of rubberized hair on each of the six sides of the instrument. The DMM must fit snugly into the cushion and box.

d) Include the instruction manual and test leads but NOT the battery.

e) Include a written list of all problems or out of specification conditions. Include the purchase order number as well as name, address and telephone number of the person who may be contacted on the problems.

f) Seal the box with wide packing tape.

g) Properly label and address the box with a typed label or indelible pen. Include a full return address.

h) If shipment is to the factory, notify Ballantine in advance. Warranty service will be accomplished at once if problems relate to defects in material and workmanship. All other service will be estimated and prior approval requested from the customer.

Ship prepaid by United Parcel Service or Registered Air Parcel Post to:

Ballantine Laboratories, Inc.
90 Fanny Road
Post Office Box 97
Boonton, New Jersey, USA 07005

The Warranty is located at the front of this manual and warrants the instrument for material and workmanship for one year. In order for the Warranty to become effective, the Warranty Registration Card included with the instrument must be fully completed and returned to Ballantine Laboratories, Inc., Boonton, New Jersey, USA within ten days of delivery.

TABLE 4-1. RECOMMENDED TEST EQUIPMENT

1. DC Voltage Standard 1 mV to 1 kV 0.01%	Fluke 332B	
2. Precision Resistors	90Ω	0.1%
	900Ω	0.1%
	9kΩ	0.1%
	90kΩ	0.1%
	900kΩ	0.1%
	9MΩ	0.1%
3. DC Current Source 10 Volt DC power supply 1 Ampere capacity with series resistors	Power Designs 6050A	
	9Ω	0.1%
	90Ω	0.1%
	900Ω	0.1%
	9000Ω	0.1%
	90kΩ	0.1%
4. DC Digital Voltmeter 100μV resolution. Off Ground capability	Ballantine 3600A	
5. AC Voltage Source	HP745A and HP746A	
6. AC Power Amplifier with Transformer	Singer LTP-11	
7. AC/DC Transfer Standard Voltmeter	Ballantine 1600A	
8. Frequency Counter	Ballantine 5725A	
9. Shunt Resistors	Ballantine 600 Series	

NOTE:

a) Although test equipment for the 3/24 should be 5 to 10 times more accurate to certify full specifications, it is possible to use a known accurate 3/24 as a working comparison unit.

b) The AC current ranges may be checked by the dc current range measurements to avoid the use of the sophisticated ac current source equipment.

4-3 GENERAL MAINTENANCE

Access Procedure

1. Disconnet battery if it is used. Remove by rear, sliding out the back panel. The battery can then be withdrawn and leads disconnected. Disconnect the AC power if it is used.

2. Remove the battery lead feed-through grommet and let the battery leads lie loosely in the instrument compartment.

3. Unscrew the two Philips retaining screws at the sides of the case near the panel.

4. Hold the front panel and slide the instrument out of its case. Some 3/24 units have a ground wire soldered between the + side of C1 and the case shield. Unsolder this wire at capacitor if necessary.

5. To reassemble the DMM, simply reverse the above procedure. Make sure case shield grounding clip or wire are properly installed.

NOTE

Always use a small 20 watt soldering iron and non-corrosive flux core solder when making repairs. Reseal the printed wiring boards with Humiseal spray to restore humidity protection.

4-4 FUSE REPLACEMENT

Fuses for current range protection (1.6A) and ohmmeter protection (100 mA) are located within the instrument.

Spare fuses are stored on the battery or in the battery compartment.

The 100mA Ohmmeter fuse is on the master board while the 1.6A current protection fuse is located on the switch deck printed wiring board.

4-5 EXTERNAL CLEANING

Clean the panel, knobs and case with a soft cloth dampened in a mild liquid dish washer detergent solution and water. DO NOT use solvents, cleaning fludis or alcohol since they will damage the finish of the instrument and void the warranty.

4-6 INTERNAL CLEANING

Internal cleaning is rarely required. Any dust may be removed with a soft brush or low pressure clean dry air. Freon TF degreaser (Miller Stevenson Company Type MS-180) may be used for severe contamination if followed by low pressure air drying. Warm water and detergent immersion wash may be used if followed by several hours of oven drying at 70°C. Always reseal the boards with Humiseal spray. Avoid getting the sealant on switch contacts.

4-7 PERFORMANCE ASSURANCE TEST

This performance test is especially suited for acceptance testing of new instruments and for routine periodic performance certification.

The instrument must perform within the listing of specifications in Section I. Measurements must be compared to the reference conditions of 23° ±1°C and 70% or less relative humidity.

Should your 3/24 not meet some of the specifications corrective maintenance and/or recalibration will be necessary. Trouble shooting hints in the following paragraphs will easily localize the problem.

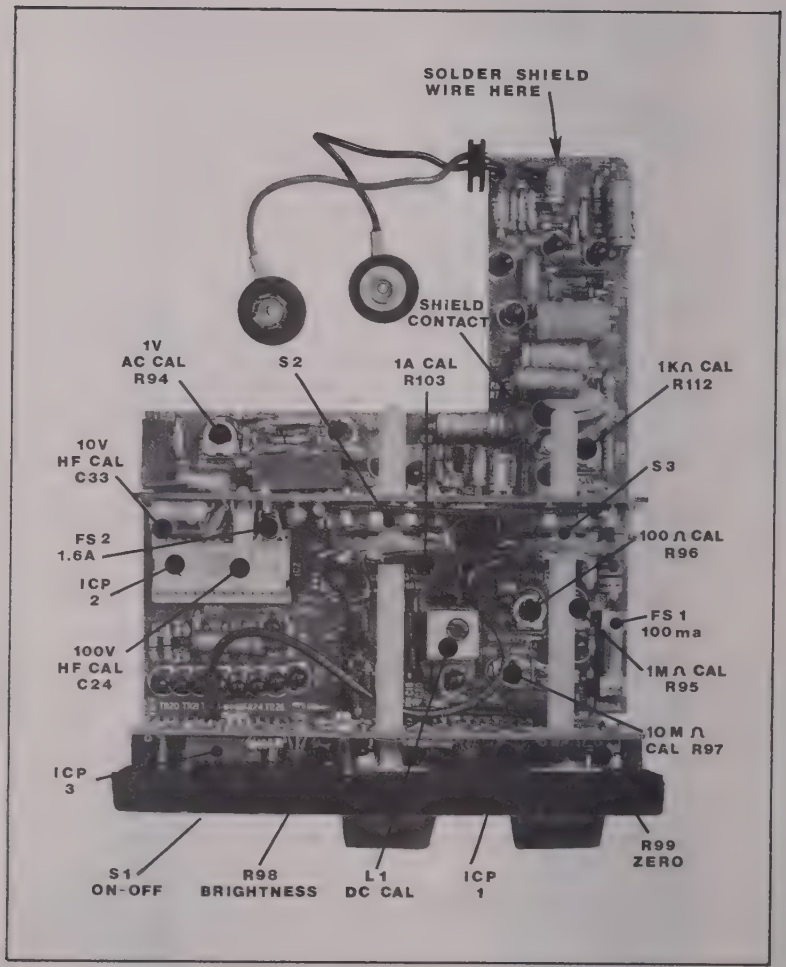


FIGURE 4-1. COMPONENT LOCATIONS

4-8 ZERO CHECK

a) Turn on the instrument. Observe the illuminated display.

b) Turn to BATT 6V MIN and 1000 mV. Observe a reading above 700 to assure battery performance.

c) Select dc and 1000 mV.

d) Short the test leads together. Observe 000 or —000 reading.

e) Adjust front panel zero control. Check range and reset for 000 or —000.

f) Select AC and 1000 mV.

g) Short the input leads together.

h) Adjust the front panel zero control and set for 000.

i) Select Ω and 1000Ω. Open test leads and observe the flashing left-hand digit.

j) Short test leads together and adjust front panel zero control to obtain 000.

k) Select Ω and 1000Ω.

l) Short leads together and re-adjust front panel zero control for 000.

m) Return to DC and 1000 mV. Short leads and set to 000. This checks the basic zero performance of the 3/24 DMM.

4-9 CALIBRATION CHECKS

To check calibration performance use the test equipment listed in Table 4-1. Use Table 4-2 for check limits.

4-10 ADJUSTMENT PROCEDURE

Use the test equipment listed in Table 4-1 to perform the adjustments listed in Table 4-3.

Note:

a) To calibrate Ω ranges, use one of the six 0.1% precision resistors. Always check "zero" especially on 100Ω range.

b) To measure dc voltage use the Fluke 332B.

c) To measure dc current, use the 10 Volt power supply and use the appropriate precision series resistor with the ammeter input of the 3/24. Measure dc voltage across the appropriate resistor with the 0.01% DVM (Ballantine 3600A)

Obtain the following voltages:

$$E = IR$$

$$900\text{mA} \times 9\Omega = 8.100 \text{ Volts}$$
$$90 \text{ mA} \times 90\Omega = 8.100 \text{ Volts}$$
$$9 \text{ mA} \times 900\Omega = 8.100 \text{ Volts}$$
$$900\mu\text{A} \times 9000\Omega = 8.100 \text{ Volts}$$
$$90\mu\text{A} \times 90 \text{ k}\Omega = 8.100 \text{ Volts}$$

During this measurement also record the dc supply voltage for use during the ac current measurements.

d) To measure ac voltage use the HP 745A ac voltage standard and the 746 adapter.

e) To measure ac current use the Singer LTP-11 ac Power amplifier and oscillator. Measure the output voltage with the Ballantine ac/dc Transfer Standard Model 1600A.

Check each range with the same resistor used in dc current calibration and set the ac output voltage from the ac power amplifier to the dc supply voltage levels measured in dc current calibration.

4-11 INPUT OFFSET CURRENT COMPENSATION

Before making adjustments, check zero on each range by shorting the input test leads together. Use the front panel zero adjust control to set the 1000 mV dc range. If after setting zero on the 1000 mV range, the 10V dc range does not read 000 ±2 digits, then input offset current must be compensated. Connect points P or Q on the printed circuit board as required.

On the 100Ω range, zero can be adjusted to offset any test lead resistance. Reset zero on 1000 mV dc range after using the 100Ω range.

TABLE 4-2. CALIBRATION CHECK LIMITS

FUNCTION	RANGE	INPUT	DISPLAY LIMITS
BATT	1000mV	None	650 to 1100
DC	1000mV	900mV	897 to 903
DC	10V	9V	8.94 to 9.06
DC	100V	90V	89.4 to 90.6
DC	1kV	900V	894 to 906
AC	1000mV	900mV 40Hz	889 to 911
AC	1000mV	900mV 20kHz	889 to 911
AC	10V	9V 40Hz	8.89 to 9.11
AC	10V	9V 20 kHz	8.89 to 9.11
AC	100V	90V 40Hz	88.9 to 91.1
AC	100V	90V 1kHz	88.9 to 91.1
AC	1kV	500V 40Hz	493 to 507
AC	1kV	500V 1kHz	493 to 507
DC	100μA	90μA	89.4 to 90.6
DC	1000μA	900μA	894 to 906
DC	10mA	9mA	8.94 to 9.06
DC	100mA	90mA	89.4 to 90.6
DC	1000mA	900mA	894 to 906
AC	100μA	90μA 40Hz	88.3 to 91.7
AC	100μA	90μA 2kHz	88.3 to 91.7
AC	1000μA	900μA 40Hz	893 to 917
AC	1000μA	900μA 20kHz	893 to 917
AC	10mA	9mA 40Hz	8.93 to 9.17
AC	10mA	9mA 20kHz	8.93 to 9.17
AC	100mA	90mA 40Hz	89.3 to 91.7
AC	100mA	90mA 20kHz	89.3 to 91.7
AC	1000mA	900mA 40Hz	893 to 917
AC	1000mA	900mA 20kHz	893 to 917
Ω	100Ω	90Ω	88.9 to 91.1
Ω	1000Ω	900Ω	889 to 911
Ω	10kΩ	9kΩ	8.89 to 9.11
Ω	100kΩ	90kΩ	88.9 to 91.1
Ω	1000kΩ	900kΩ	889 to 911
Ω	10MΩ	9MΩ	8.81 to 9.19

TABLE 4-3. ADJUSTMENTS

Perform Adjustment in the Order Listed

Function	Range	Input Voltage	Adjust	Reading	Note
DC	1000mV	1V dc	L1	1000	Reverse input polarity and check reading
AC	1000mV	1V ac 1kHz	R94	1000	When making ac measurements, instrument must be in its case.
AC	100V	100V ac 1kHz	C24	1000	
AC	10V	10V ac 20kHz	C33	1000	
DC	1000mA	1A	R103	1000	
Ω	1000Ω	900Ω	R112	900	
Ω	10Ω	9Ω	R97	900	
Ω	100kΩ	90kΩ	R96	900	
Ω	1000kΩ	900kΩ	R95	900	

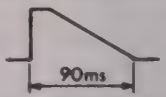
NOTE: Only 9 adjustments calibrate the 3/24 DMM. If these are performed, the instrument is fully calibrated and for typical use it is not mandatory to perform the complete range by range check. Note also that the dc current shunts set the ac current ranges and ac current calibration is not needed if the ac/dc converter and voltage ranges have been properly adjusted. This calibration method for ac current range testing simplifies the more complicated ac current range test certification procedure.

4-12 TROUBLESHOOTING

All voltages measured with respect to '0' Volt line, with 10 MΩ input impedance voltmeter or oscilloscope. Voltages measured with 8.5V battery.

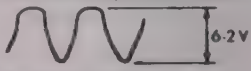
a) NO DISPLAY ON ONE OR MORE DIGITS. Check:
1. Battery voltage with a separate meter, 6.2 to 9V
2. Power supply: 14 V measures between 13.6 and 25.1 V
   10 V measures between 9.6 and 17.3 V
   5 V measures between 5.2 and 9.1 V
3. Pulse output at TR35 collector. 5V pk-pk, duration 0.1 to 0.8 ms, dependent on brightness control.
4. TR42 collector for approximately 200 kHz square wave drive to IC2. Voltage pk-pk approximately same as 0 to 10V supply bus.
5. TR19 to 27 and TR28 to 34 collectors are switching.
6. IC2 outputs.
7. VZ; 7.0V (approximately)
8. VR; 4.5V (approximately)

b) NO MEASUREMENT ON 1V DC Range. Apply 1V and check:
1. Input wiring and switching continuity on 1V DC range.
2. Reset pulse every 300 ms approximately at TR17 base; 0.6V pk-pk.
3. Ramp at TR17 collector.
4. Comparator output at TR37 collector; 9.5V pk-pk (approximately.)



5. VX relative to 10V; 1.5V
6. VX comparator output at TR36 collector; 9.5V pk-pk (approximately)
7. Check 4 and 6 are present on pins 24 and 23 of IC2.

c) NO MEASUREMENT ON AC VOLTAGE RANGES. Select 1V range AC and with the input leads connected together, measure the DC level at TR12 collector (6 to 7.5V). Apply 1V ac at 1 kHz to the input and check:
1. Input signal at switch side of C10
2. Signal at TR12 collector.



3. dc voltage proportional to input signal at R111, C15 junction.
4. Switch continuity between ac/dc converter output and the input comparator.

d) NO MEASUREMENT ON 10V, 100V, 500/1000V AC or DC RANGES. Check the input switching and ac/dc voltage attenuator.

e) NO ME \SUREMENT ON AC/DC CURRENT RANGES Check:
1. FS2 2. Input Switching 3. R34 to 37

f) NO MEASUREMENT ON OHMS RANGES Check:
1. FS1
2. Input Switching
3. TR14 base 3.2V (approximately)
4. TR13 to 14
5. TR13 emitter ranging resistors and switching.

SECTION 5
REPLACEABLE PARTS LIST

The replacement parts listed are available from the vendors listed or from Ballantine Labs. Your local Ballantine Field Engineering Representative may also carry a stock of parts and can assist you. If pricing quotations are required for parts and or repairs your local representative will give the most rapid service or you may contact the Ballantine Factory directly.

When ordering replacement parts always give the following information:

a) Instrument Model number
b) Serial number
c) Ballantine Part number
d) Schematic Symbol number
e) Identification of the part

Ballantine will do its best to improve the instrument and make changes in style of components and replacement parts. Replacement parts may differ in appearance from those found in your instrument but are always equal or superior in performance. Where necessary minor mechanical modifications may be required in the replacement of components.

Parts are generally available locally for most replacements. The parts list calls out the recommended vendors where applicable.

The Manufacturer Code is taken from Federal Supply Code Cataloging Handbooks H4-1, H4-2, and H4-3. Ballantine Code is 50423.

The following parts coding are used:

CVC	Capacitor, Variable, Ceramic
CEP	Capacitor, Fixed, Plastic
CCD	Capacitor, Ceramic, Disc
CYF	Capacitor, Mylar, Foil
CMD	Capacitor, Mica, Dipped
CMM	Capacitor, Mica, Molded
CEA	Capacitor, Electrolytic, Aluminum
CET	Capacitor, Electrolytic, Tantalum
DGP	Diode, General Purpose
DZG	Diode, Zener, General Purpose
DRP	Diode, Bridge, Power
FLT	Filter
ICP	Integrated Circuit
TRQ	Transistor
RFF	Resistor, Fixed, Film
RFC	Resistor, Fixed, Composition
RFW	Resistor, Fixed, Wirewound
SWC	Switch
LMP	Lamp
TRX	Transformer

Resistors may generally be replaced by Corning Electronics (CCW) type N-55, N-60 and C-32. Allen Bradley composition resistors type EB are also used.

SCHEMATIC REF		BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C	1	C71C191CA	CEA 32. UF 10 V TUBULAR	73445	AMPRX SERIES C426AR/D32
C	2	C71C440CA	CEA 200. MF 10 V TUBULAR	56423	AMPRX SERIES C426AR/D200
C	3	C71C070CA	CSF 33C.0PF5010. VK	25065	SIEMENS B31110A050330K
C	4	C71C070CA	CSF 33C.0PF5010. VK	25065	SIEMENS B31110A050330K
C	5	C70C355CA	CCD 22 NF 200 V K 10%	92741	GOODALL TYPE 621M
C	6	C71C440CA	CEA 200. MF 10 V TUBULAR	56423	AMPRX SERIES C426AR/D200
C	7	C71C440CA	CEA 200. MF 10 V TUBULAR	56423	AMPRX SERIES C426AR/D200
C	8	C70C352CA	CEA 125 UF 16 V K 10%	73445	AMP TYP C426AR/E125
C	9	C72CC05CA	CCD 0.1UF 30.0 VK +-10%	71590	CTL CK-104
C	10	C71C070CA	CSF 33C.0PF5010. VK	25065	SIEMENS B31110A050330K
C	11	C70C576CA	CCD 10 NF 150 V T 40%	71590	CTL TYP DD-103 CAP
C	12	C72CC07CA	CCD 56.0PF 500.0 VK +-10%	71590	CTL DD-560
C	13	C70C371CA	CMM 47 NF 200 V K 10%	56289	SPRAGUE TYPE 192P
C	14	C70C232CA	CPM 1 UF 200 V K 10%	05023	CORNELL-DUBILIER TYPE PU
C	15	C70C162CA	CSM 330 NF 50 V M 20%	92741	GOODALL TYPE 602
C	16	C70C576CA	CCD 10 NF 150 V T 40%	71590	CTL TYP DD-103 CAP
C	17	C71C234CA	CYF 22. NF 100 V DC	84171	ELMENCO TYPE 1MDF-1-223
C	18	C70C238CA	CMM 47C.0PF 500.0V	05023	CORNELL-DUBILIER K060
C	19	C72CCC4CA	CCD 27.0PF 500.0 VK +-10%	71590	CTL DD-270
C	20	C70C576CA	CCD 10 NF 150 V T 40%	71590	CTL TYP DD-103 CAP
C	21	C72CCC4CA	CCD 27.0PF 500.0 VK +-10%	71590	CTL DD-270
C	22	C71C152CA	CYF 1C. NF 50 V TUBULAR	73445	AMPRX SERIES C426AR/D20C
C	23	C70C386CA	CEA 150 UF 6 V	56289	SPG TYP 150D
C	24	C71C167CA	CWC C.7/6PF TRIMMER	50423	ADV.PN-29421
C	25	C71C193CA	CTT 4.7PF 1KV +-1PF	95275	VITRAMON VY13C ADV 3337
C	26	C70C295CA	CMM 47 PF 300 V J 5%	84171	ARCO DM5-EC470J
C	27	C71C194CA	CYF 1. NF 50 V +-1%	50423	
C	28	C70C561CA	CCD 1 NF 1 KV K 10%	84171	ARC TYP CCS-102
C	29	C71CC39CA	CYF 47C. NF 100 V DC	84171	ELMENCO TYPE 1MDF4474
C	30	C71C163CA	CCD C.1UF 100.0 V GMV	72982	ERIE 7060-100/651-104M
C	31	C71C163CA	CCD C.1UF 100.0 V GMV	72982	ERIE 7060-100/651-104M
C	32	C71C132CA	CEA 10. UF 25. VT +75,-10	56289	SPRAGUE TE1204 STYL 30D
C	33	C71C155CA	CYC 2-12PF PC POLY TRIMMER	73445	AMPRX C01CKA/10E
C	34	C70C361CA	CEA 150 UF 15 V K 10%	56289	SPG TYP 150D
C	35	C72CCC5CA	CCD C.1UF 30.0 VK +-10%	71590	CTL CK-104
C	36	C72CCC5CA	CCD C.1UF 30.0 VK +-10%	71590	CTL CK-104
C	37	C72CCC5CA	CCD C.1UF 30.0 VK +-10%	71590	CTL CK-104
C	38	C71C155CA	CCD 2.2NF 500.0 V 25%+-20%	72982	ERIE 801 Z5U 2.2NF20%500
C	39	C70C573CA	CCD 330 PF 500 V K 10%	71590	CTL TYP CE-331
D	3	C5C792CCA	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
D	4	C5C792CCA	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
D	5	C5C792CCA	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
D	6	C5C792CCA	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
D	7	C51CC01CA	DGP 1N3595	12954	DICKSON ELECTRONICS
D	8	C5C792CCA	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
D	9	C5C792CCA	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
D	10	C5C792CCA	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
D	11	C5C5491CA	DGP 1N4003	04713	MOTOROLA
D	12	C5C5491CA	DGP 1N4003	04713	MOTOROLA
D	13	C5C792CCA	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
D	14	C5C5491CA	DGP 1N4003	04713	MOTOROLA
D	15	C5C5491CA	DGP 1N4003	04713	MOTOROLA
D	16	C5C5491CA	DGP 1N4003	04713	MOTOROLA
D	17	C5C5491CA	DGP 1N4003	04713	MOTOROLA
D	18	C51CC01CA	DGP 1N3595	12954	DICKSON ELECTRONICS
D	19	C51CC01CA	DGP 1N3595	12954	DICKSON ELECTRONICS
D	20	C5C792CCA	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
D	22	C5C792CCA	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
D	23	C5C792CCA	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
D	24	C51CC01CA	DGP 1N3595	12954	DICKSON ELECTRONICS
D	25	C5C792CCA	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
D	26	C51CC11CA	DGP 1N4007	12954	DICKSON ELECTRONICS
D	27	C5C792CCA	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
D	28	24100550CA	DCP DL 33 3DIGIT LED NUMERIC	56579	LITRONIX DL33
D	29	16100110CA	LMP LED MINUS SIGN LAMP-RED	56579	LITRX RED LIT4
D	30	C5C792CCA	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
FS	1	15100120CA	FLS 100 MA 5X20MM MED ACT	75915	LITTELFUSE 211.100
FS	2	15100130CA	FLS 1.6A 5X20MM MED ACT	75915	LITTELFUSE 21101.6

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
IC 1	1CC5412CA	TRQ RCA CA 3046 (TRANS ARRAY	86684	RCA
IC 2	241CC54CA	ICP MOS DIGITAL 24PIN 3/24	50423	ADV 32755 GEN INSTR
ILP 1	14C3479CA	PLT NE 51 H.G.E.	50423	STATE ELECTRON.PARTS-G.E.
L 1	03100300A	CLV OSCILLATOR TUNE 3/24 LL	50423	
R 1	12124400A	RFF 26.1 K 500 MW F+-1%	16299	CGW NA 60
R 2	1212440CA	RFF 26.1 K 500 MW F+-1%	16299	CGW NA 60
R 3	1212564CA	RFF 464.0 K 500 MW F+-1%	16299	CGW NA 60
R 4	1212564CA	RFF 464.0 K 500 MW F+-1%	16299	CGW NA 60
R 5	1212480CA	RFF 68.1 K 500 MW F+-1%	16299	CGW NA 60
R 6	1212440CA	RFF 10.0 K 500 MW F+-1%	16299	CGW NA 60
R 7	1212400CA	RFF 10.0 K 500 MW F+-1%	16299	CGW NA 60
R 8	1212468CA	RFF 82.5 K 500 MW F+-1%	16299	CGW NA 60
R 9	1212465CA	RFF 47.5 K 500 MW F+-1%	16299	CGW NA 60
R 10	1212465CA	RFF 47.5 K 500 MW F+-1%	16299	CGW NA 60
R 11	1212456CA	RFF 33.2 K 500 MW F+-1%	16299	CGW NA 60
R 12	1212468CA	RFF 51.1 K 500 MW F+-1%	16299	CGW NA 60
R 13	1212779CA	RFF 9.53M 500.1MW F+-1%	03888	PYF PME-55
R 15	1212400CA	RFF 10.0 K 500 MW F+-1%	16299	CGW NA 60
R 16	1212500CA	RFF 100.0 K 500 MW F+-1%	16299	CGW NA 60
R 17	1212416CA	RFF 14.7 K 500 MW F+-1%	16299	CGW NA 60
R 18	1201238CA	RFC 10.0 M 250 MW K+-10%	01121	A-B TYP CB
R 19	12C6865CA	RFF 10.0 M 500 MW F+- 1%	03888	PYF TYP PME-70
R 20	1212272CA	RFF 562.0 500 MW F+-1%	16299	CGW NA 60
R 21	1212417CA	RFF 15.0 K 500 MW F+-1%	16299	CGW NA 60
R 22	1212388CA	RFF 6.81K 500 MW F+-1%	16299	CGW NA 60
R 23	1201238CA	RFC 10.0 M 250 MW K+-10%	01121	A-B TYP CB
R 24	1201238CA	RFC 10.0 M 250 MW K+-10%	01121	A-B TYP CB
R 25	1201238CA	RFC 10.0 M 250 MW K+-10%	01121	A-B TYP CB
R 26	1201375CA	RCF348C.0 K 500 MW F+- 1%	19701	ELT TYP DC-1/2
R 27	1212548CA	RFF 316.0 K 500 MW F+-1%	16299	CGW NA 60
R 28	1212788CA	RFF 33. K 250 MW 0.25%	03888	PYF PME-55
R 29	1212781CA	RFF 3.26K 250 MW 0.25%	03888	PYF PME-55
R 30	1212782CA	RFF 318. 250 MW 0.25%	03888	PYF PME-55
R 31	1212739CA	RFC 2.7 M .25WJ	01121	A-B TYP CB2755
R 32	1212472CA	RFF 56.2 K 500 MW F+-1%	16299	CGW NA 60
R 33	1212220CCA	RFF 100.0 500 MW F+-1%	16299	CGW NA 60
R 34	1212783CA	RFF 8.82K 250 MW 0.25%	03888	PYF PME-55
R 35	1212784CA	RFF 832 250 MW 0.25%	03888	PYF PME-55
R 36	1212785CA	RFF 88.2 250 MW 0.25%	03888	PYF PME-55
R 37	1212786CA	RFF 8.8 250 MW 0.25%	03888	PYF PME-55
R 38	12C1887CA	RFW 1.0 F+- 1%	80031	MPC TYP M59
R 39	1212300CA	RFF 1.0 K 500 MW F+-1%	16299	CGW NA 60
R 40	1212490CA	RFF 86.6 K 500 MW F+-1%	16299	CGW NA 60
R 41	1212774CA	RFF 47.5 K 250MW 8+-0.5%	16299	CGW NA-55
R 42	1212775CA	RFF 32.4 K 250MW 8+-0.5%	16299	CGW NA-55
R 43	1212464CA	RFF 46.4 K 500 MW F+-1%	16299	CGW NA 60
R 44	1212500CCA	RFF 100.0 K 500 MW F+-1%	16299	CGW NA 60
R 45	1212388CCA	RFF 6.81K 500 MW F+-1%	16299	CGW NA 60
R 46	1212416CA	RFF 14.7 K 500 MW F+-1%	16299	CGW NA 60
R 47	1212400CA	RFF 10.0 K 500 MW F+-1%	16299	CGW NA 60
R 48	1212400CA	RFF 10.0 K 500 MW F+-1%	16299	CGW NA 60
R 49	1212400CCA	RFF 10.0 K 500 MW F+-1%	16299	CGW NA 60
R 50	1212400CCA	RFF 10.0 K 500 MW F+-1%	16299	CGW NA 60
R 51	1212400CCA	RFF 10.0 K 500 MW F+-1%	16299	CGW NA 60
R 52	1212400CCA	RFF 10.0 K 500 MW F+-1%	16299	CGW NA 60
R 53	1212400CCA	RFF 10.0 K 500 MW F+-1%	16299	CGW NA 60
R 54	1212400CCA	RFF 10.0 K 500 MW F+-1%	16299	CGW NA 60
R 55	1212524CA	RFF 178.0 K 500 MW F+-1%	16299	CGW NA 60
R 56	1212256CA	RFF 383.0 500 MW F+-1%	16299	CGW NA 60
R 57	1212256CA	RFF 383.0 500 MW F+-1%	16299	CGW NA 60
R 58	1212232CA	RFF 215.0 500 MW F+-1%	16299	CGW NA 60
R 59	1212232CA	RFF 215.0 500 MW F+-1%	16299	CGW NA 60
R 60	1212232CA	RFF 215.0 500 MW F+-1%	16299	CGW NA 60
R 61	1212232CA	RFF 215.0 500 MW F+-1%	16299	CGW NA 60

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R 62	1212232QA	RFF 215.Q 500 MW F+-1%	16299	CGW NA 60
R 63	1212232QA	RFF 215.Q 500 MW F+-1%	16299	CGW NA 60
R 64	1212232QA	RFF 215.Q 500 MW F+-1%	16299	CGW NA 60
R 65	1212232QA	RFF 215.Q 500 MW F+-1%	16299	CGW NA 60
R 66	1212400QA	RFF 10.Q K 500 MW F+-1%	16299	CGW NA 60
R 67	1212400QA	RFF 26.1 K 500 MW F+-1%	16299	CGW NA 60
R 68	1212400QA	RFF 26.1 K 500 MW F+-1%	16299	CGW NA 60
R 69	1212400QA	RFF 26.1 K 500 MW F+-1%	16299	CGW NA 60
R 70	1212480QA	RFF 68.1 K 500 MW F+-1%	16299	CGW NA 60
R 71	1212216QA	RFF 147.Q 500 MW F+-1%	16299	CGW NA 60
R 72	1212472QA	RFF 56.2 K 500 MW F+-1%	16299	CGW NA 60
R 73	1212524QA	RFF 178.Q K 500 MW F+-1%	16299	CGW NA 60
R 74	1212480QA	RFF 68.1 K 500 MW F+-1%	16299	CGW NA 60
R 75	1212432QA	RFF 21.5 K 500 MW F+-1%	16299	CGW NA 60
R 76	1212140QA	RFF 26.1 500 MW F+-1%	16299	CGW NA 60
R 77	1212140QA	RFF 26.1 500 MW F+-1%	16299	CGW NA 60
R 78	1212432QA	RFF 21.5 K 500 MW F+-1%	16299	CGW NA 60
R 79	1212480QA	RFF 68.1 K 500 MW F+-1%	16299	CGW NA 60
R 80	1212524QA	RFF 178.Q K 500 MW F+-1%	16299	CGW NA 60
R 81	1212557QA	RFF 392.Q K 500 MW F+-1%	16299	CGW NA 60
R 82	1212557QA	RFF 392.Q K 500 MW F+-1%	16299	CGW NA 60
R 83	1212480QA	RFF 68.1 K 500 MW F+-1%	16299	CGW NA 60
R 84	1212776QA	RFF 5.05M 250MW 1% 100PPM	16299	CGW NA-55
R 85	1212776QA	RFF 5.05M 250MW 1% 100PPM	16299	CGW NA-55
R 86	1212776QA	RFF 5.05M 250MW 1% 100PPM	16299	CGW NA-55
R 87	1212533QA	RFF 221.Q K 500 MW F+-1%	16299	CGW NA 60
R 88	1212380QA	RFF 6.81K 500 MW F+-1%	16299	CGW NA 60
R 89	1212777QA	RFF 1245. K 250MW.25% 100PPM	03888	PYF PME-55
R 90	1212229QA	RFF 200.Q 500 MW F+-1%	16299	CGW NA 60
R 91	1212778QA	RFF 101.85K 250MW.25% 100PPM	03888	PYF PME-55
R 92	1212600QA	RFF 1.00M 500 MW F+-1%	16299	CGW TYP NA 65
R 93	1212532QA	RFF 215.Q K 500 MW F+-1%	16299	CGW NA 60
R 94	CS10C560A	RWC 2.5 KMIN CPEN PC TRIM	73445	AMPRX E097AD/2.5K
R 95	CS10C370A	RWC 500.Q K PC TRIMPOT	73445	AMPEREX E097AB/500K
R 96	CS10C380A	RWC 200.Q PC TRIMPOT	73445	AMPEREX E097AB/200E
R 97	CS10C570A	RWC 5.Q KMIN CPEN PC TRIM	73445	AMPRX E097AD/5M
R 98	CS10C580A	RWC 100. MIN CPEN PC TRIM	73445	AMPRX E097AC/100E
R 99	CS10C610A	RWC 2.5 KMIN CPEN PC 3/24	50423	TYPE RN-58
R 100	1212552QA	RFF 348.Q K 500 MW F+-1%	16299	CGW NA 60
R 101	1212480QA	RFF 68.1 K 500 MW F+-1%	16299	CGW NA 60
R 102	1212408QA	RFF 12.1 K 500 MW F+-1%	16299	CGW NA 60
R 103	CS10C058A	RWC 100. MIN CPEN PC TRIM	73445	AMPRX E097AC/100E
R 104	1212533QA	RFF 221.Q K 500 MW F+-1%	16299	CGW NA 60
R 105	1212600QA	RFF 1.Q M 500 MW F+-1%	16299	CGW TYP NA 65
R 106	1212550QA	RFF 332.Q K 500 MW F+-1%	16299	CGW NA 60
R 107	12C9818QA	RFC 4.7 M 250 MW K+-10%	01121	A-B TYP CB
R 108	1212200QA	RFF 100.Q 500 MW F+-1%	16299	CGW NA 60
R 109	1212452QA	RFF 34.8 K 500 MW F+-1%	16299	CGW NA 60
R 110	1212400QA	RFF 10.Q K 500 MW F+-1%	16299	CGW NA 60
R 111	1212564QA	RFF 464.Q K 500 MW F+-1%	16299	CGW NA 60
R 112	CS101C20A	RWC 10. KMIN CPEN PC TRIM	73445	AMPRX E097AD/10K
R 113	1212364QA	RFF 4.64K 500 MW F+-1%	16299	CGW NA 60
R 114	1212552QA	RFF 348.Q K 500 MW F+-1%	16299	CGW NA 60
S 1	251CC220A	SWC SLIDE MIN DPDT	78488	STACKPOLE SS-91-1
S 2	251C066GL	SWC 3/24 S2 ROTARY ASY	50423	BLI
S 3	251CC67GL	SWC 3/24 S3 ROTARY ASY	50423	BLI

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
TR 1	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 2	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 3	1C100180A	TRQ 2N4061 PNP GEN PURPOSE	01295	TEXAS INST
TR 5	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 6	1C100180A	TRQ 2N4061 PNP GEN PURPOSE	01295	TEXAS INST
TR 7	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 9	1C100590A	TRQ 2N3819 FET(USED IN PAIRS	50423	BLI 3/24
TR 10	1C100590A	TRQ 2N3819 FET(USED IN PAIRS	50423	BLI 3/24
TR 11	1C100180A	TRQ 2N4061 PNP GEN PURPOSE	01295	TEXAS INST
TR 12	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 13	1C100590A	TRQ 2N3819 FET(USED IN PAIRS	50423	BLI 3/24
TR 14	1C100180A	TRQ 2N4061 PNP GEN PURPOSE	01295	TEXAS INST
TR 15	1C100430A	TRQ NPN .3W 40VCE 2N3904	04713	MOTOROLA OR EQUIV.
TR 16	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 17	1C100180A	TRQ 2N4061 PNP GEN PURPOSE	01295	TEXAS INST
TR 18	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 19	1C100180A	TRQ 2N4061 PNP GEN PURPOSE	01295	TEXAS INST
TR 24	1C100180A	TRQ 2N4061 PNP GEN PURPOSE	01295	TEXAS INST
TR 25	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 26	1C100180A	TRQ 2N4061 PNP GEN PURPOSE	01295	TEXAS INST
TR 27	1C100180A	TRQ 2N4061 PNP GEN PURPOSE	01295	TEXAS INST
TR 28	1C100010A	TRQ TRANSISTOR TYPE 2N2369	04713	MOTOROLA
TR 28	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 29	1C100010A	TRQ TRANSISTOR TYPE 2N2369	04713	MOTOROLA
TR 30	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 31	1C100010A	TRQ TRANSISTOR TYPE 2N2369	04713	MOTOROLA
TR 32	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 33	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 34	1C100010A	TRQ TRANSISTOR TYPE 2N2369	04713	MOTOROLA
TR 35	1C100180A	TRQ 2N4061 PNP GEN PURPOSE	01295	TEXAS INST
TR 36	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 37	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 38	1C100180A	TRQ 2N4061 PNP GEN PURPOSE	01295	TEXAS INST
TR 39	1C100180A	TRQ 2N4061 PNP GEN PURPOSE	01295	TEXAS INST
TR 40	1C100180A	TRQ 2N4061 PNP GEN PURPOSE	01295	TEXAS INST
TR 41	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 42	1C100020A	TRQ TRANSISTOR TYPE 2N930	04713	MOTOROLA
TR 42	1C100430A	TRQ NPN .3W 40VCE 2N3904	04713	MOTOROLA OR EQUIV.

BALLANTINE INSTRUMENTATION

ANALOG VOLTMETERS

Series 3035A Broadband AC Voltmeter/Amplifiers: Average responding voltmeters, 100 μV to 300 V. Frequency range 5 Hz to 15 MHz usable to 25 MHz. Log or linear voltage scales. Midband accuracy ±(1% f.s. + 0 rdg.). Five models.

Series 323 True RMS Wideband AC Voltmeters: Logarithmic voltage scales. No vulnerable thermocouples. Eight models. 300 μV to 300 V full scale. Accuracy ±1% f.s. or ±2% rdg., whichever is better. 2 Hz – 20 MHz frequency range.

Series 303 Logarithmic Broadband AC Voltmeter/Amplifiers: 300 μV to 1,000 V, 6 MHz. Accuracy ±1% rdg. Five models.

DIGITAL VOLTMETERS/AC CONVERTERS

3600A DC Digital Voltmeter: 100 μV. 5 digit, 39.999 count. ±(0.01% rdg. + 0.005% f.s.) ±(1/2 count). Programmable.

Model 3575A AC-DC True RMS Converter: 10 mV to 1,000 V, 10 Hz to 18 MHz. 1 μV resolution accuracy ±(0.2% rdg. + 0.2% f.s.). Crest factor 10:1. Programmable.

3571A AC-DC Average Responding Converter: 10 mV to 300 V f.s. 1 μV resolution. <30 Hz to >10 MHz. Midband accuracy ±(0.2% rdg. + 0.01% f.s.). Programmable.

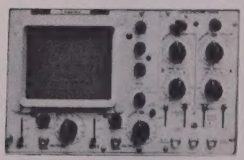
DIGITAL FREQUENCY COUNTERS/TIMERS

5500A 70 MHz Counter-Timer/5700A 512 MHz Frequency Counter/ 5725A 90 MHz Economy Counter. A family of digital frequency counters and universal counters with sensitivities to 10 mV rms, resolution to 100 μsec, and many automatic features. Programmable. Competitively priced.

OSCILLOSCOPES

Portable Dual Trace Oscilloscopes:

1010A	10 MHz;	5 mV/cm;	100 ns/cm
1066B	20 MHz;	1 mV/cm;	50 ns/cm sweep. Delay line.
1040A	40 MHz;	50 μV/cm;	20 ns/cm delayed and mixed sweeps.
All 8 x 10 cm CRT.		Light weight.	Economic pricing.



MP MASTER
MA31999